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ROBUST DATA TRANSMISSION OVERWIRELESS CHANNEL BASED ON TURBO CODED OFDM

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ABSTRACT: In this paper data transmission system incorporating both turbo coding and OFDM is used. The data is encoded using turbo encoder of rate1/3 where turbo code achieves bit error rate performance close to Shannon limit. Using of OFDM transmission technique allows transmitting high data rate over frequency selection channel. We have analyzed BER performance of OFDM with turbo encoder and without turbo encoder in the multi path channel with respect to Eb/N0. Wireless data transmission using turbo encoder with OFDM gives better result than without OFDM. We also analyzed multipath carrier data transmission using turbo coded OFDM is giving better results with compared to single carrier transmission.

KEY WORDS: OFDM, BER, SHANNON LIMIT TURBO CODED OFDM

(I) INTRODUCTION

The telecommunications' industry is in the midst of a veritable explosion in Wireless technologies. Once exclusively military, satellite and cellular technologies are now commercially driven by ever more demanding consumers, who are ready for seamless communication from their home to their car, to their office, or even for outdoor activities. With this increased demand comes a growing need to transmit information wirelessly, quickly, and accurately. To address this need, communications engineer have combined technologies suitable for high rate transmission with forward error correction techniques. The latter are particularly important as wireless communications channels are far more hostile as opposed to wire alternatives, and the need for mobility proves especially challenging for reliable communications. For the most part, Orthogonal Frequency Division Multiplexing (OFDM) is the standard being used throughout the world to achieve the high data rates necessary for data intensive applications that must now become routine.

Orthogonal Frequency Division Multiplexing (OFDM) is a Multi-Carrier Modulation technique in which a single high rate data-stream is divided into multiple low rate data-streams and is modulated using sub-carriers which are orthogonal to each other. Some of the main advantages of OFDM are its multi-path delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. Also one other significant advantage is that the modulation and demodulation can be done using IFFT and FFT operations, which are computationally efficient.

In this Paper forward error correction is performed by using turbo codes. The combination of OFDM and turbo coding and recursive decoding allows these codes to achieve near Shannon's limit performance in the turbo cliff region. Turbo codes were first presented at the International Conference on Communications in 1993. Until then, it was widely believed that to achieve near Shannon's

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bound performance, one would need to implement a decoder with infinite complexity or close. Parallel concatenated codes, as they are also known, can be implemented by using either block codes (PCBC) or convolution codes (PCCC). PCCC resulted from the combination of three ideas that were known to all in the coding community: The transforming of commonly used non-systematic convolution codes into systematic convolution codes. The utilization of soft input soft output decoding. Instead of using hard decisions, the decoder uses the probabilities of the received data to generate soft output which also contain information about the degree of certainty of the output bits. This is achieved by using an interleave. Encoders and decoders working on permuted versions of the same information. An iterative decoding algorithm centered on the last two concepts would refine its output with each pass, thus resembling the turbo engine used in airplanes. Hence, the name Turbo was used to refer to the process.

(II) OFDM

The principle of orthogonal frequency division multiplexing (OFDM) modulation has been in existence for several decades. However, in recent years these techniques have quickly moved out of textbooks and research laboratories and into practice in modern communications systems. The techniques are employed in data delivery systems over the phone line, digital radio and television, and wireless networking systems.

OFDM signals are typically generated digitally due to the difficulty in creating large banks of phase locks oscillators and receivers in the analog domain. Fig 1 shows the block diagram of a typical OFDM transceiver. The transmitter section converts digital data to be transmitted, into a mapping of subcarrier amplitude and phase. It then transforms this spectral representation of the data into the time domain using an Inverse Discrete Fourier Transform (IDFT). The Inverse Fast Fourier Transform (IFFT) performs the same operations as an IDFT, except that it is much more computationally efficiency, and so is used in all practical systems. In order to transmit the OFDM signal the calculated time domain signal is then mixed up to the required frequency.

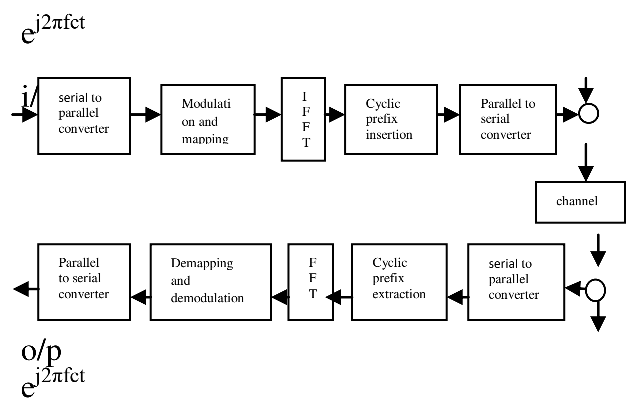

Fig 1 Block diagram of a basic OFDM transceiver.

The receiver performs the reverse operation of the transmitter, mixing the RF signal to base band for processing, then using a Fast Fourier Transform (FFT) to analyze the signal in the frequency domain. The amplitude and phase of the sub carriers is then picked out and converted back to digital data. The IFFT and the FFT are complementary function and the most appropriate term depends on whether the signal is being received or generated. In cases where the signal is independent of this distinction then the term FFT and IFFT is used interchangeably.

II. TURBO CODES

The combination of Turbo code with the OFDM System transmission is called as Turbo coded OFDM (TC-OFDM) which can yield significant improvement in terms of lower energy needed to transmit data. Turbo codes were first presented at the International conference on communications in 1993.Until then it was widely believed that to achieve near Shannon's

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bound performance, one would need to implement a decoder with infinite complexity or close to it. Parallel concatenated codes, as they are also known, can be implemented by using either block codes (PCBC) or convolution codes (PCCC). A trellis structure or state diagram is used at the encoder side and with using a hard decision we decode the data stream required. FANO Algorithm under Sequential decoding is used in this Paper.

(a) Turbo Encoding:

The encoder for a Turbo code is parallel concatenated convolution code. The block diagram of encoder is shown in Figure 1.The binary input data sequence is represented by dk=(d1,…….d N).The input sequence is passed into the input of a convolution encoder ENC1 and a coded bit stream, xpk1 is generated. The data sequence is then interleaved that is, the bits are loaded into a matrix and read out in a way so as to spread the position of the input bits. The bits are often taken out in a pseudo random manner. The interleaved data sequence is passed to Second convolution encoder ENC2, and a second coded bit stream xpk2 is generated. The code sequence that is passed to the modulator for transmission is a multiplexed stream consisting of systematic code bits xsk and parity bits from both the first encoder $x_p{}^{k1}$ and the second encoder $x_p{}^{k2}$.

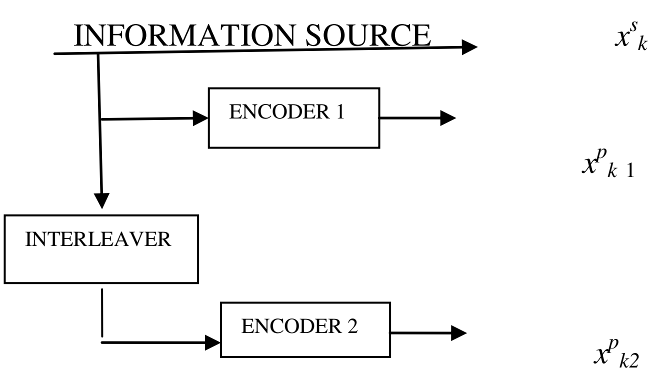

Figure 2 - Structure of a turbo Encoder

(b) RSC Components Codes

Encoder1 and Encoder 2 are recursive systematic convolution codes (RSC) that is, The encoder has two output sequence; One is the data sequence: $x_k^s=\{x_1^s\ldots\ldots\ldots x_N^s\}$Other is the parity sequence: $x_k^p=\{x_1^p\ldots\ldots\ldots x_N^p\}$

(c) Turbo Decoding

A block diagram of a turbo decoder is shown in Figure 3.The input to the turbo decoder is a sequence of received code values,=$\{y_k{}^s,\ y_k{}^p\}$ from the demodulator. The turbo decoder consists of a two component decoder-DEC1 to decode sequence from ENC1 and DEC2 to decode sequence from ENC2. DEC1 take s as its input, the received sequence systematic values $\{y_k{}^s\}$ and the received sequence parity values $y_{k1}{}^p$, belonging to the first encoder ENC1.The output of a DEC1 is a sequence of hard estimates EXT1 of the transmitted data is d_k. EXT1 is called extrinsic data, that does not contain any

Information which was given to DEC1 to DEC2. This information is interleaved and passed to the second DEC2. The inter leaver is identical to that in the encoder (Figure1).DEC2 takes as its input the (interleaved) systematic received values $yk\ s$ or the sequence of received parity values $yk\ p2$ from the second ENC2, along with the interleaved form of the extrinsic information EXT1 provided by the first encoder ENC1.

DEC2 outputs a set of values, which when de-interleaved using an inverse form of inter leaver, constitutes hard estimates EXT2 of the transmitted data sequence dk. This extrinsic data formed without the aid of parity bits from the first code is feedback DEC1.

This procedure is repeated in a iterative manner. The iterative decoding process adds greatly to the BER performance of turbo

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codes.DEC2 outputs a value ^(dk), a likelihood representation of the estimate of dk.This maximum likelihood value takes the account of transmitting a bit „0" or „1" based on the systematic and parity information from both component codes. For this we used FANO algorithm under the sequential decoding.

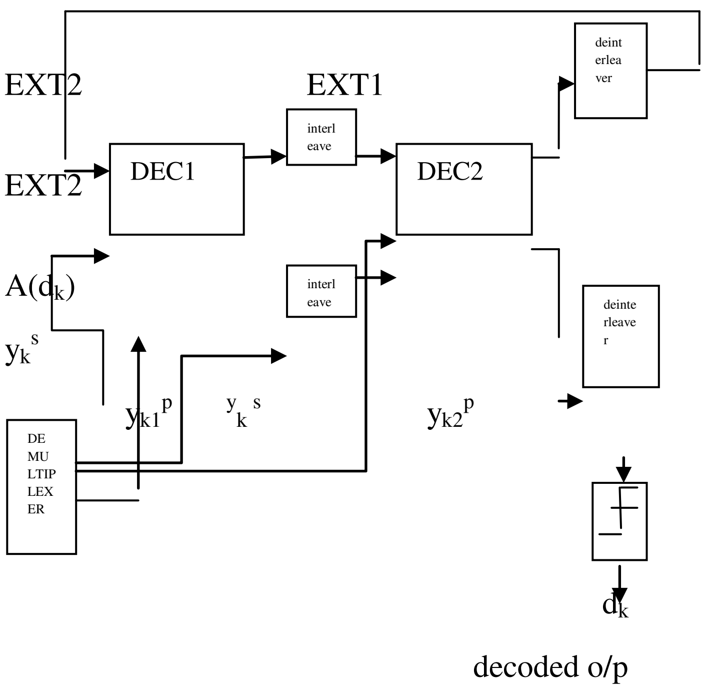

Figure 3 Turbo Decoder Structure.

The Block diagram of Turbo Decoder is shown in figure 4.The decoder also uses the parallel concatenated decoding scheme. The iterative decoding scheme uses the a posteriori probability (APP) decoder as the constituent decoder, an interleaver, and a deinterleaver. Decoder 1 & Decoder 2 use the same trellis structure and decoding algorithm.

III. TURBO CODED OFDM SYSTEM

OFDM is the multi carrier modulation method in which single high data rate is divided in to multiple low rate data stream and modulated using SCs. These SCs are orthogonal to each other. The main advantages of OFDM are its efficient spectral usage by allowing overlapping in the frequency domain and multi-path delay spread tolerance. Other significant advantage is that the modulation and demodulation can be done using IFFT and FFT operations, which are very efficient computationally. OFDM has become a very popular modulation method in high-speed wireless communications. OFDM is a suitable technology for high data rate transmission with FEC methods over wireless channels. The combination of turbo codes with the OFDM transmission is called T-COFDM. It can yield significant improvements in terms of lower energy needed to transmit data. There is a large potential gain in using the iterative property of turbo decoders where soft bit estimates are used together with the known pilot symbols.

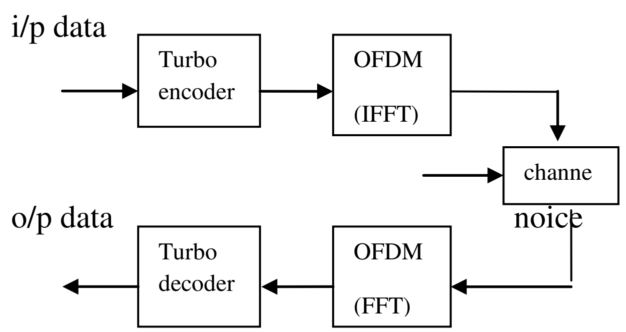

FIG 4 TURBO CODED OFDM SYSTEM

IV. SIMULATION RESULTS

In the following figure turbo decoder performance over AWGN channel for BPSK modulation is observed.

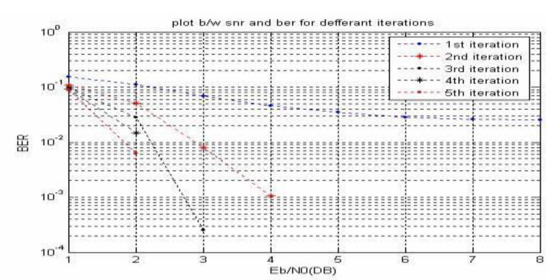

FIG 5 BER vs. SNR plot for turbo codes for different iterations

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In this following figure Bit Error Rate performance of OFDM without turbo coding is shown.

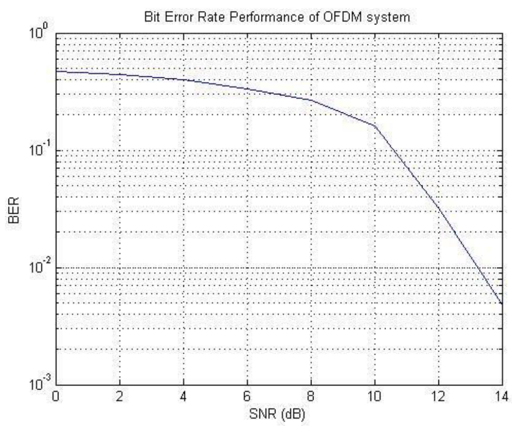

FIG 6 BER of OFDM vs SNR

The following simulation result showing BER performance of Turbo Coded OFDM

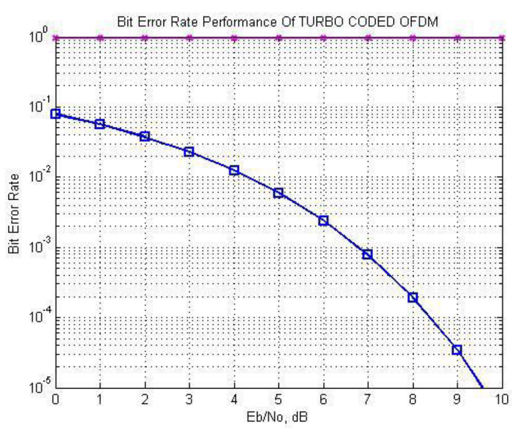

FIG 7 BER Performance Of Turbo Coded OFDM

(V) CONCLUSION:

To conclude, this major paper gives the detail knowledge of a current key issue in the field of communications named Orthogonal Frequency Division Multiplexing (OFDM). We focused our attention on turbo codes and their implementation. We described the encoder architecture. In our case, the code is the result of the parallel concatenation of two identical RSCs. The code can be punctured in order to fulfill bit rate requirements. The decoder succeeded in its duty thanks to the decoding algorithms that it is built around. We focused mainly on the study of the MAP. We discovered that the power of the scheme came from the two individual decoders performing the MAP on interleaved versions of the input. Each decoder used information produced by the other as a priori information and outputted a posteriori information. We elaborated on the performance theory of the codes Then we tied concepts of OFDM and turbo coding with a target-based, modulation scheme. First I developed an OFDM system model then try to improve the performance by applying forward error correcting codes to our uncoded system. From the study of the system, it can be concluded that we are able to improve the performance of uncoded OFDM by convolution coding scheme. Further improvement on the performance has been achieved by applying turbo coding to uncoded OFDM system. Turbo codes with low order decoding iterations have been evaluated. The SNR performance for BER 10−2 and 10−4, that are suitable for speed and data applications, are analyzed.

Scope of future work:

- VLSI implementation of turbo codes.
- Multi path channel can also be investigated.

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